Fractured Tills, Ohio's Ground Water Resources, and Public Policy Considerations Addressed by DRASTIC Maps[1]

Julie Weatherington-Rice, Ava Hottman (*in memorium*), Earl Finbar Murphy, Ann D. Christy, and Michael Angle, Bennett and Williams Environmental Consultants Inc., Columbus, OH 43231; former Assistant Chief OEPA Surface Water Division, Columbus, OH; Moritz College of Law, The Ohio State University, Columbus, OH 43210; Department of Food, Agricultural, and Biological Engineering, The Ohio State University, Columbus, OH 43210; Ohio Department of Natural Resources, Division of Water, Columbus, OH 43224

Abstract. The public health of all Ohioans is dependent on land use decisions that preserve the quality of Ohio's water resources. If a potentially polluting site is located over fractured glacial tills, those fractures could hasten contaminant transport from surface contamination to underlying ground water. This paper addresses public policy, government programs, and the law as they affect land use decisions in fractured environments. A review of programs in Ohio identified a number of efforts currently in place that, if modified, could include ground water pollution potential mapping (DRASTIC) and the concept of fracture flow in guiding science-based land use decisions. Two of these programs, the Sole Source Aquifer designation and the Wellhead/Source Water Protection Program, are detailed. In addition, two Ohio law cases directly addressing ground water resource protection are described: Cline v. American Aggregates and CF/Water et al. v. Schregardus. The latter case is the first in the United States to explicitly state that fractures must be taken into consideration by the regulatory agency when reviewing a permit to install a potentially contaminating land use.

OHIO J SCI 106 (2):64-73, 2006

INTRODUCTION

Over 40 percent of Ohioans rely on ground water for their source of drinking water. Rural residents typically use their own private well at home for their regular daily water supply. In addition, many rural and non-rural Ohioans rely on the approximately 1350 community and non-community public ground water supplies in Ohio. The ability of those private wells and those public suppliers to provide safe, clean water is directly related to the quality of the raw water being collected for distribution, possible treatment, and the local supplier's ability to protect their resource (Smith 2004).

Thanks to the federal Safe Drinking Water Act and its various amendments, public water supplies have water quality standards that have to be met. For the rural Ohioan using a private water well, those water quality standards don't apply. Once the private house well has met a screening for total coliform bacteria and nitrates by the local health district, that well will often not be tested again until the home is sold to a new owner. The public health of Ohioans is subject to land-use decisions that have the potential to impact the quality of Ohio's water resources. For the most part, those land-use decisions are not made by scientists, but by people who trust that the local, state, and federal programs that they follow will keep their water resources safe.

Fractured glacial tills and the ability of those fractured settings to both recharge ground water and transport environmental pollution has been recognized by a small group of the scientific community since the 1880s (Read 1880; Brockman and Szabo 2000; Szabo 2006). However, moving that knowledge to the general population, to the decision makers and enforcement agencies charged with protecting Ohio's surface and ground water supplies has been a far more difficult undertaking. It is the loss of safe ground water resources due to contamination, at the local level, that has created the greatest level of hardships, sending local decision makers searching for protection strategies. For example, this pattern of wellfield contamination has been experienced along the Mad River-Great Miami River Buried Valley Aquifer from Urbana to Cincinnati during the last 30 years or more. Communities along that prolific ground water reserve continue to scramble to find new and/or replacement wellfields that are not already contaminated by historic land uses, including those located on the surrounding uplands covered by fractured glacial tills.

Regardless of these devastating local experiences, public policy and the law, for the most part, still function under the mistaken illusion that glacial tills and other fine-grained glacially derived materials are impermeable and, therefore, excellent locations for the construction of potentially contaminating land uses that may affect current and/or reserved public raw water supplies.

This misconception has been propagated, in part, by the time lag that exists between new discoveries in science and publication of those discoveries in nationally and/or internationally accepted textbook references. For example, the Domenico and Schwartz (1997) text *Physical and Chemical Hydrogeology*, as recently as 1997, considered glacial till to be impermeable, even though the research group from the Waterloo Institute for Groundwater Research at the University of Waterloo, Ontario, Canada had been writing about fractured glacial till in peer-reviewed hydrology journals since the mid 1970s. It wasn't until the publication of Ward and Trimble's *Environmental Hydrology* (2004), that the concept of permeable, fractured glacial till was incorporated

[1]Manuscript received and in revised form (#00-).

into an internationally recognized English-language textbook and reference published in the United States.

If documentation of the concept of fractured till in standard hydrologic references takes almost 30 years to achieve, one cannot be surprised that regulations that people have to comply with and the laws governing those regulations, which always lag behind science, have not yet embraced a working understanding of the implications of fractured glacial till and other fine-grained materials as they relate to surface and ground water contamination.

There are, in addition, two other issues that continue to complicate the situation. Wherever public policy, based on federal legislation, is set by the US Department of Agriculture (USDA) or the US Environmental Protection Agency (US EPA), these policies are set nationally, a "one-size-fits-all" management approach. That approach might have been successful in a country like Denmark, which is small and has one basic geologic setting for almost all of the country. But the United States is a very large country, encompassing many geologic settings controlled by myriads of variables. It is virtually impossible to imagine that a "one-size-fits-all" management approach could possibly succeed.

The one notable exception to this process is the Source Water Protection Program that was created to expand the Wellhead Protection Program, in the 1996 Amendments to the Safe Drinking Water Act. Here, the program design was left up to the states, relying on the state level implementation team to discover and apply the newest concepts in hydrology and ground water recharge as they relate to the local settings. This implementation nation wide has had varied results.

The uniform rejection of policies that "one-size-fits-all" would have been reached years ago, if the decision makers, who controlled the formulation and application of public programs, were extensively trained in geology and soil science. But, for the most part, they are not, and therein lies the second overriding complication. The individuals who set the policies and establish the programs on the federal level, the public administrators who administer policies and programs especially at the local level, and the courts following previous rulings and precedents as well as utilizing strict procedural and evidentiary rules aren't prepared to consider the current state of the science. They simply do not have the extensive technical background and years of scientific experience necessary to consider whether it is even possible for the earth to behave in the manner that has been assigned to it by these various programs. If the earth cannot function as the policies and programs decree, then land uses assigned to "safe" locations, may very well not have the natural protection that the permitting and regulating agencies assume.

The Ohio Fracture Flow Working Group (OFFWG) is well aware of this "fracturing" of public programs caused by the time-lag that exists between what scientists and engineers working on the leading edge of the research know about how water and contaminants reach our water reserves and the incomplete and/or outdated knowledge base that supports most public policy and legal decisions, especially at the federal and local levels. It is not realistic to expect that a state-based initiative will be able to alter federal decision making processes, but success is possible at home. Education, based on new research, of decision makers on state and local levels, is key. To that end, the OFFWG holds field days, workshops, and symposia for the professional community (Weatherington-Rice and others 2000) and have authored the first special issue of *The Ohio Journal of Science* "Fractures in Ohio's Glacial Tills" (Weatherington-Rice and Christy 2000). We offer the papers included in this second special issue to further the educational outreach.

It is not enough to discover the underlying natural processes that control the movement of water and contaminants through fine-grained glacially related materials. Only if that knowledge is made available and then translated into public policy decisions and legal requirements will benefit be realized by the people of Ohio. Fortunately, for all of Ohio, there is a program, the county based Ground Water Pollution Potential (GWPP) mapping effort, carried out by the Ohio Department of Natural Resources (ODNR) Division of Water (DOW) that has, since 1995, built an understanding of "fracture flow" in unlithified fine-grained materials into their county-based DRASTIC mapping program (Weatherington-Rice and others 2006). While many state and local decision makers may not be experts in the field of ground-water recharge and contaminant transport, they don't have to be, because ODNR has provided them with a screening tool that has the expertise already built in. This tool can assist local governments during their comprehensive planning processes in defining those areas where groundwater pollution potential is greatest and pro-actively redirecting high impact commercial and industrial land uses to areas where greater suitability exists. With recent advances in Geological Information System (GIS) technology, digital DRASTIC layers can also be utilized by local governments in defining aquifer recharge areas and developing long range planning policy to insure the ongoing preservation of these environmentally significant resources in perpetuity.

MATERIALS AND METHODS

While this paper addresses an important scientific issue, this is not a scientific paper. Rather, this paper addresses public policy, public programs and the law, necessitating a slightly different approach to data collection. The first step in the research was to identify which state agencies would be typically involved with land-use decision making that could affect contaminant transport through fracture flow to underlying ground water resources. Those agencies were all identified in Ohio's Groundwater Protection Strategy, certified by Governor Celeste in 1987, and subsequently represented in the Inter-Agency Ground Water Advisory Council (IGWAC) which functioned in Ohio from the late-1980s until the mid-1990s. The group of six state agencies and affiliated federal agencies now function under the title of the "State Ground Water Coordinating Committee" and do not require the level of public input that existed during the previous IGWAC structure. The identified Ohio

agencies whose activities interact with Ohio's ground water are the Ohio Environmental Protection Agency (OEPA), Ohio Department of Natural Resources (ODNR), Public Utilities Commission of Ohio (PUCO), Ohio Department of Health (ODH), Ohio Department of Agriculture (ODA), and Ohio Department of Transportation (ODOT). The USDA Natural Resources Conservation Service (NRCS) and the US Geological Survey (USGS) also support the committee.

The second step was to identify historic local, regional, and statewide ground water protection strategies to see if they either encompassed and/or could encompass the concept of fracture flow in their protection strategies. The third effort was to identify the case law that related to the broader issue of ground water protection and, where available, to the more specific issue of fracture flow.

These review efforts were well beyond the technical expertise encompassed by the scientists and engineers who have been responsible for most of the papers presented in these two special issues. To undertake a credible effort, the OFFWG turned to members of the group who are expert in the fields of planning, public policy, and the law, especially environmental and water law. This effort represents an overview of the subject at hand, and a more fully developed effort, published in a suitable professional journal or law review, is warranted.

RESULTS

A review of programs identified a number of efforts in place that, through modification of the program and/or revision of the base documentation, could include the concept of fracture flow and DRASTIC mapping as they relate to ground water protection. Most of these programs are designed to address a specific land use for which protection of the ground water is only one of many competing goals. There are, however, two programs that have as their primary goal the protection of Ohio's ground water resources. Both of these programs have their roots in the Safe Drinking Water Act, specifically the 1986 and 1996 Amendments. The earliest program identified here in Ohio was the US EPA Safe Drinking Water Act Sole Source Aquifer designation and protection program. That regional program is locally supported by the Safe Drinking Water Act's Wellhead Protection Program (now expanded to the Source Water Protection Program) whose areas of protection have slowly but surely been created for almost all of the public water supply well fields in Ohio (Smith 2004).

These other activities are found on Table 1. Since the law lags behind the science, it is not surprising to find only a few references in case law and law review articles that reference fractured till and/or DRASTIC mapping. Those few references are here discussed.

DISCUSSION

Protection by Sole Source Aquifer Designation

Ground water protection programs are not new to Ohio. There were efforts underway on the local and regional level to protect ground water as early as the late 1970s. Most of these efforts, however, were linked to Ohio's buried valley aquifers and/or the northwest Ohio carbonate bedrock aquifers. The concept of a Sole Source Aquifer (SSA) designation (US EPA 2004a) was advanced with the 1986 amendments to the federal Safe Drinking Water Act (1974, Public Law 93-523) (US EPA 2004b). Some local and regional communities, not having an Ohio model to adopt, eagerly began the lengthy petition process for Sole Source Aquifer designation from US EPA. To date, there are five separate designated Sole Source Aquifers in Ohio protecting parts or all of 20 counties. They include the Pleasant City SSA (sand and gravel, southern Guernsey County), the Upper and Lower Great Miami River Valley SSA (sand and gravel, 2 applications, 14 counties in southwest Ohio), the Catawba Island SSA (carbonate bedrock, Ottawa County), and the Western Allen County Combined SSA (sand and gravel and carbonate bedrock, portions of five counties). Their locations are shown on Figure 1 (OEPA 2004).

None of these existing efforts, however, fully took into account the lack of protection afforded to the underlying aquifers from the overlying glacial till. In a very rudimentary way, the Western Allen County Combined SSA (Bennett & Williams 1990) did identify areas of greater and lesser recharge and, therefore, vulnerability.

Two new Sole Source Aquifer petitions are currently in the development stage. They are found in two separate geographic sections of Ohio. To date, the most progress has been achieved by the MICHINDOH SSA petition effort, organized to protect the sand and gravel buried outwash aquifer centered around the St. Joseph River watershed (five counties) in southern MICHigan, northeast INDiana, and northwest OHio (MICHINDOH). Clearly, fracture flow plays a significant role in ground water recharge and protection for that aquifer system. That recognition was built into the recently published Ground Water Pollution Potential (DRASTIC) map for Williams County, Ohio (Angle and others 2003). However, since sections of the Sole Source Aquifer lie in Indiana and Michigan, those areas outside Ohio will not have the same level of information developed for them, increasing the challenge to the petitioners to develop a standardized risk evaluation applicable to the total area.

The other effort is the Tuscarawas River Buried Valley SSA petition (potentially up to 12 counties), which traverses Ohio from the river's headwaters in glaciated portions of northeast Ohio (all or parts of five counties) to the unglaciated areas of eastern Ohio (all or parts of seven counties). Fracture flow in both unlithified fine-grained glaciated materials and in bedrock are significant mechanisms of regional recharge to the buried valley aquifer. Since the area has GWPP mapping efforts that both pre-date and post-date the revision to fracture flow in glacial till (Weatherington-Rice and others 2006), the county efforts are not uniform in assigning "fractured" values to the glacially covered portions of the valley. That inconsistency in the base data will need to be factored into the final standardized risk evaluation application.

While Sole Source Aquifer designation has the advantage of covering large geographic areas and bringing

TABLE 1

Programs regulated in Source Water Protection areas. Modified from Ohio EPA Web pages.

Program	Activity	Applies to the protection area for Public Water System Types	Water Source	DRASTIC		Notes:
				Currently Applies?	Modification Needed?	
Biosolids (Sewage Sludge) Program	Land application Staging Stockpiling Storage	Community	Ground Water	No	No	These activities are prohibited in the indicated areas.
Bureau of Underground Storage Tank Regulations	Petroleum Underground Storage Tank Cleanup	Community Non-community, Non-transient Transient, Non-Community	Ground Water	No	Yes	Ground water under site is considered drinking water source if the site or surrounding area is located within a drinking water source protection area.
Concentrated Animal Feeding Operations	Manure Storage and Treatment Facilities	Community Non-community, Non-transient Transient, Non-Community	Ground Water	Yes	Yes	These activities are prohibited in the indicated areas unless ODA finds the structure will be at least as protective as the other requirements of the rule.
Livestock Environmental Permitting Program	Permitting	Community Non-community, Non-transient Transient, Non-Community	Ground Water	Yes	Yes	Permits require documentation of the location of the site in relation to the indicated drinking water source protection areas.
Construction & Demolition Debris Landfill Program	Permitting	Community Non-community, Non-transient Transient, Non-Community	Ground Water	No	Yes	Permits require documentation of the location of the site in relation to the indicated drinking water source protection areas.
	Operation	Community Non-community, Non-transient Transient, Non-Community	Ground Water	No	Yes	A ground water monitoring well system is required in the indicated protection areas.
Industrial Solid Waste Landfill Program	Siting	Community Non-community, Non-transient Transient, Non-Community	Ground Water	No	Yes	This activity is prohibited in the indicated areas.

TABLE 1 (*Cont.*)

Programs regulated in Source Water Protection areas. Modified from Ohio EPA Web pages.

Program	Activity	Applies to the protection area for Public Water System Types	Water Source	DRASTIC Currently Applies?	DRASTIC Modification Needed?	Notes:
Underground Injection Control Program, Class V Wells	New Motor Vehicle Waste Disposal Wells	Community Non-community, Non-transient Transient, Non-Community	Ground Water	No	Yes	This activity is prohibited in the indicated areas.
	Existing Motor Vehicle Waste Disposal Wells	Community Non-community, Non-transient Transient, Non-Community	Ground Water Surface Water	No	Yes	Must be closed no later than 1 Jan 2007.
Residual Waste Landfill Program	Siting	Community Non-community, Non-transient Transient, Non-Community	Ground Water	No	Yes	This activity is prohibited in the indicated areas.
Sanitary Landfill Program	Siting	Community Non-community, Non-transient Transient, Non-Community	Ground Water	No	Yes	This activity is prohibited in the indicated areas.
Voluntary Action Program	Brownfield Cleanup	Community Non-community, Non-transient Transient, Non-Community	Ground Water	Yes	Depends on Source of Contamination	The aquifer is considered to be from a "Critical Resource Aquifer."
	Request for an Urban Setting Designation	Community	Ground Water	Yes	Depends on Source of Contamination	The owner of the public water system has a fully endorsed drinking water source protection plan. The owner of the public water system consents to the designation in writing. The capture zones of *any* potable water supply wells within one-half mile of the property boundary do not extend under the property.
Hazardous Waste* Landfill Program	Siting	Community Non-community, Non-transient Transient, Non-Community Community	Ground Water Surface Water	No	Yes	This activity is not listed in the OEPA review list but should be included.

* This activity not included in the Ohio EPA review program.

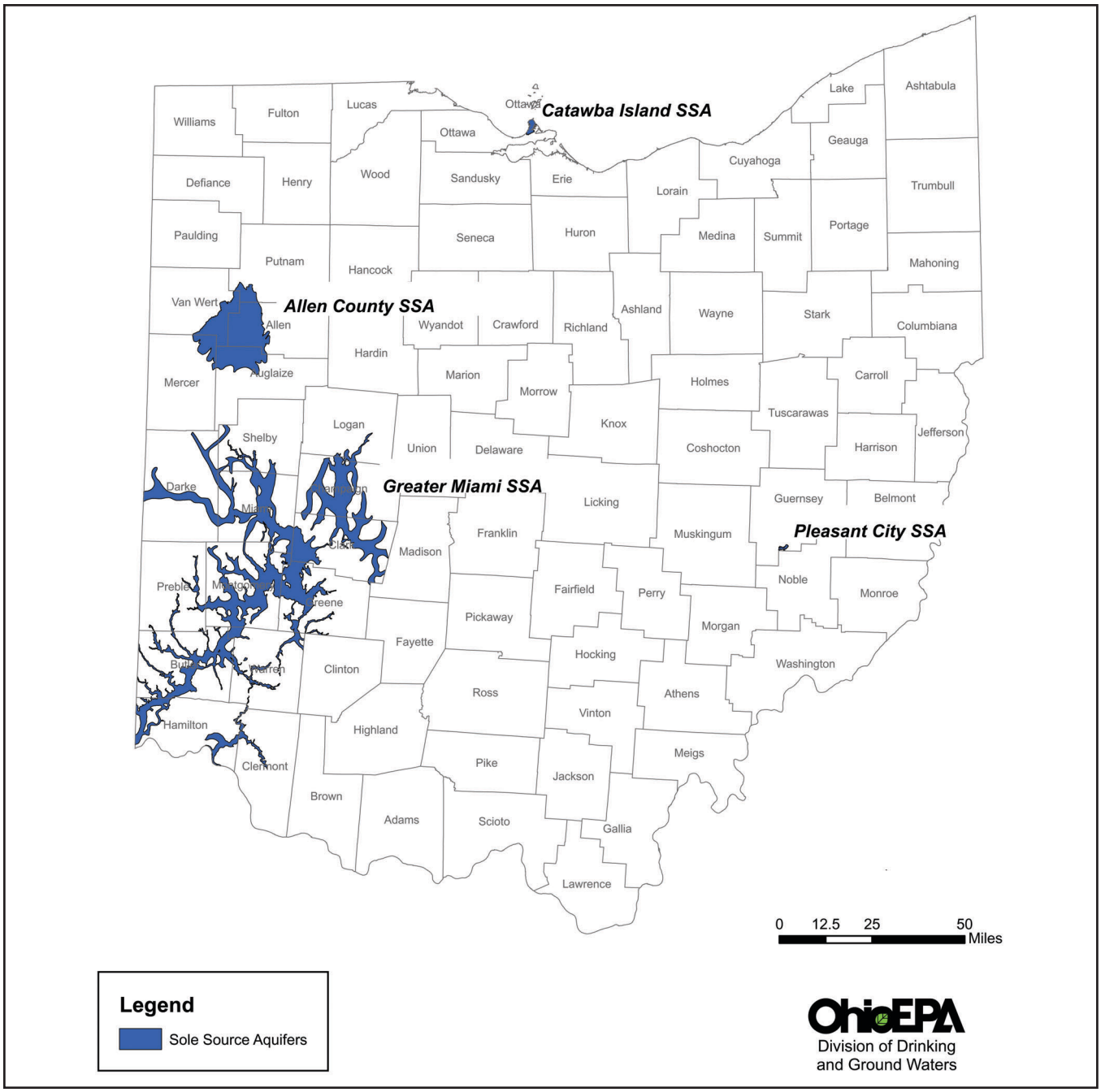

FIGURE 1. Ohio's Sole Source Aquifer areas (modified from OEPA 2004).

protection to rural populations who use private water wells for their water supplies, the actual regulatory powers of the designation are relatively limited and weak. Sole Source Aquifer designation was developed to bring a second level of review to insure that any activity funded by federal tax dollars would minimize or avoid negative environmental impacts to the region's vulnerable and irreplaceable ground water supply. If a community applies for federal funds to upgrade wastewater treatment, if road improvements are made using funds from the Federal Highway Administration, or any other local public effort involving federal moneys, a special review is required to insure that the activity does not adversely affect the designated Sole Source Aquifer.

But the benefits of Sole Source Aquifer designation reach beyond the simple required federal review. In Ohio, several land uses are precluded and/or subject to special review if they are constructed in an area designated as a Sole Source Aquifer. The most notable example of this preclusion is the siting of a solid waste landfill over a previously designated Sole Source Aquifer. The Ohio Administrative Code (3745-27-07(H)(2)(c)) currently states:

> "The sanitary landfill facility is not [to be] located above an aquifer declared by the federal government under the "Safe Drinking Water Act" to be a sole source aquifer prior to the date of receipt of the permit to install application by Ohio EPA."

While the 2003 amendments to Ohio's Solid Waste regulations have granted an applicant the possibility of

appeal to the OEPA Director, the applicant would need to satisfy the Agency that the aquifer would, indeed, be protected. The other Ohio program that is most commonly associated with Sole Source Aquifer designation is the requirement for the installation of double-walled storage tanks for potentially contaminating materials, such as gasoline or diesel fuel stored at service stations.

Sole Source Aquifer designation is even more important as an educational and awareness tool. When an area of the state comes together to make an application, they are recognizing the importance of that water supply for the continued economic viability of the region. Letters of support are gathered from local governmental bodies, reminding the communities of the importance of their ground water. While not all Sole Source Aquifer designations have spurred the level of protection seen for the Great Miami River Buried Valley Aquifer protection program, currently administered by the Miami Conservancy District (MCD), that effort gives Ohioans a model to work towards. An example of the Conservancy's educational outreach program can be viewed at their ground water web site (MCD 2004).

Protection by Wellhead/Source Water Protection Programs

The Wellhead Protection Program first established under the Safe Drinking Water Act 1986 Amendments (US EPA 2004c) has now been replaced/expanded in the 1996 Amendments to the Safe Drinking Water Act by the Source Water Protection Program (US EPA 2004d). This effort addresses a smaller geographic area but provides a more powerful level of protection to ground water resources. Unlike the Sole Source Aquifer application process, by law all community and non-community public water suppliers have to undertake the designation and evaluation effort. The program is a formal requirement of the 1996 Amendments to the Safe Drinking Water Act. The effort entails a four step process (US EPA 2004d). The general location of those public systems relying on ground water can be seen on Figure 2.

While the Sole Source Aquifer program is relatively weak, the Wellhead Protection Program and the Source Water Protection Program have the ability to be incorporated into local zoning and planning efforts as overlay zoning districts. This makes it possible to actually administer land-use decisions in these areas of protection at the local level. While challenge exists on the local level to carry out such efforts, especially when areas needing protection are outside the jurisdictional boundaries of the owners of the public water supply, these hurdles have been successfully overcome as demonstrated by city of Dayton (US EPA 2004e).

On the federal and state level, there are a number of specific land-use practices that are either restricted and/or require permits before they can be sited within the Source Water Protection area of public water supplies relying on ground water resources. Most of those programs do not require the screening of DRASTIC maps as part of their siting criteria, but they could. Informally, DRASTIC maps are often reviewed at the agency level when an application for a new land use is reviewed. However, to compel the mandated use of DRASTIC maps would require the development of a coherent set of regulations within the Ohio Administrative Code sections that control the siting process for each potentially contaminating land use. Those land uses as defined by OEPA (2004) are listed in Table 1.

When reviewing Table 1, the reader will note that in order to function as a screening tool for many land use applications, the DRASTIC map information would need to be modified. That modification is necessary because DRASTIC maps were developed to predict the potential for a contaminant spilled at the surface, moving with infiltrating water, to reach the underlying aquifer (Aller and others 1987). Most of these other land uses actually are facilities that would be installed into the ground. For land uses located below existing ground surface, the DRASTIC site numbers can be modified by removing the protection of the soil, flattening the topography to 0 to 2% slope for its site footprint or excavation area, and reducing the thickness of the vadose zone by the distance the facility lies below the earth's surface. This modification is appropriate for underground storage tanks or landfills still under active management. In some cases, insertion of synthetic liners or compacted zones may provide additional protection. If the land use results in a pond or pool of contaminated water that remains in place for long periods of time creating a continuous recharge source such as an animal manure lagoon or an abandoned landfill, additional modifications would have to be made. It is possible that even then, DRASTIC values would underestimate the contamination potential. Additional research is needed to verify this application of DRASTIC.

Support from the Law

The law lags behind the science, often at a great distance and at a glacial pace. That common statement applies in Ohio as well as in the rest of the United States. However, because of the great courage of some of Ohio's citizens, case law has been created by the Ohio Supreme Court that lets the science in. Since the mid-1800s, Ohio functioned under the 1861 decision, Frazier v. Brown (1861), which called the movements of Ohio's ground water "occult." In 1984, after many years of effort on the part of Ohio's scientific community to bring science into decision making, Rose Cline succeeded where the scientific community had failed. The Cline property is located in Jackson Township, Franklin County, OH. Her house foundation was shaken and she lost the water in her well as the nearby American Aggregates limestone quarry continued to expand and deepen their main pit. In order to continue to quarry at depth, pumps removed water that collected in the pit. American Aggregates fully acknowledged that they may have affected Rose Cline's well, but under Frazer v. Brown, they were not operating illegally if they dewatered her well. In Cline v. American Aggregates (1984), the Ohio Supreme Court stated that the primary goal for ground water protection was that "the legal system conforms to hydrologic fact." After years of legal efforts, Rose Cline's neighbors finally got

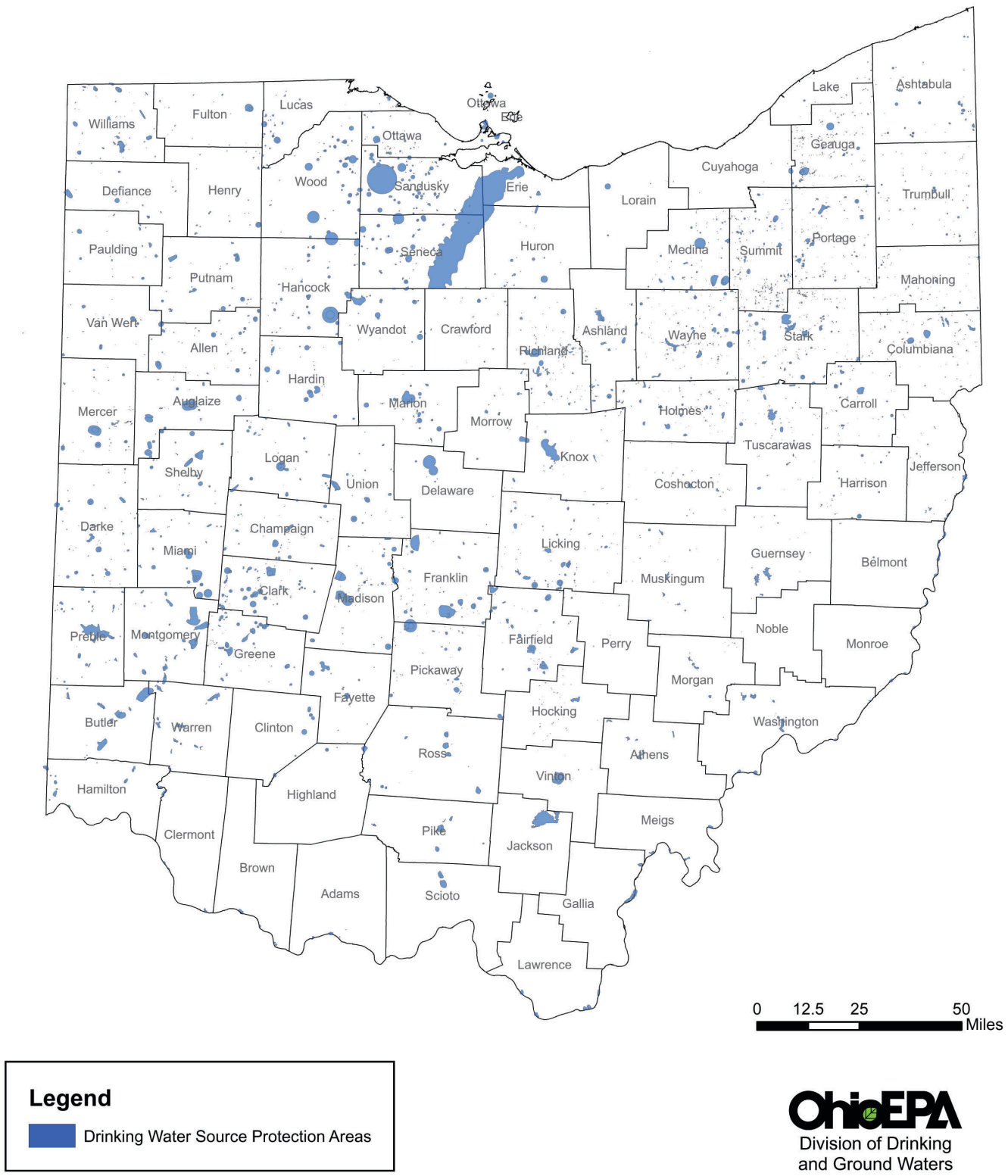

FIGURE 2. Drinking Water Source Protection areas in Ohio (modified from OEPA 2004).

their water supplies replaced. Rose Cline, unfortunately, died before the final remedies were in place. This landmark decision let the science in the legal door and opened the way for Ohioans to promote the protection of Ohio's ground water through the courts, when such an effort is necessary.

The case most relevant to the issue of fracture flow in glacial tills was the CF/Water et al. v. Schregardus (1998) appeal to the Ohio Environmental Review Appeals Commission. In this case, it was upheld through the Tenth District Court of Appeals in Franklin County (1999) that fractures were present under the proposed Clarkco Landfill in German Township, Clark County, and that OEPA's director and staff could not claim to

have been unaware of evidence of fracturing at the site when reviewing the Permit to Install application for a solid waste landfill. It was ruled that the Environmental Review Appeals Commission was correct in sending the case back to OEPA for reconsideration in light of the clear evidence of fracturing, recognizing that fracturing was an element of the geology and therefore part of the evidence to be considered by the agency in issuing a permit to install.

This Ohio decision flows naturally from the Village of Wilsonville v. SCA Services, Inc. (1981) decision from Illinois where a landfill, constructed over an aquifer used for a public drinking water supply, leaked through fractures in the glacial till, contaminating the drinking water. The Wilsonville experience was fresh in the minds of those developing DRASTIC for US EPA in the mid-1980s. The final solution in Illinois was to dig up the landfill and move it. The final solution in Ohio at the Clarkco site was to not build the proposed landfill. The two existing landfills on the adjoining property are now undergoing remedial investigation and feasibility studies under Superfund.

In 1989, the *Yale Law Journal* included a legal note that recommended DRASTIC be used as a basis for ranking ground water vulnerability on a national scope (Ng 1989). Ng further suggested a single federal agency be tasked with oversight of all ground water protection activities.

SUMMARY AND CONCLUSIONS

Six state agencies and two federal agencies are responsible for the protection of Ohio's ground water resources. However, for the most part, these agencies provide only tangential protection. Only two programs, identified in the federal Safe Drinking Water Act and its 1986 and 1996 Amendments directly address the issue of ground water protection. Those two programs are the regionally applied Sole Source Aquifer systems (five areas in Ohio currently designated with two more applications under development) and the more localized Wellhead Protection Program (now Source Water Protection Program), which applies to the approximately 1350 public water supplies utilizing ground water in Ohio. Most private well owners in Ohio fall outside of these two programs.

While current practice often does not acknowledge the critical importance of fractures as conduits for ground water contamination, this factor has been incorporated into the ODNR Division of Water's county-based Ground Water Pollution Potential mapping effort since 1995 (Weatherington-Rice and others 2006). Where they are available, review of these maps are used as part of the Source Water Protection Program. For most other potentially contaminating land uses that are constructed below the ground surface, DRASTIC map numbers need to be modified for potential ground water vulnerability screening.

There exists a small body of case law in Ohio that calls for the protection and preservation of Ohio's ground water resources. Cline v. American Aggregates (1984) places the responsibility for replacement of a lost ground water resource on the owners of the dewatering land use. This case has been argued to apply to contamination of the ground water resource as well. In another case, C/F Water et al. v. Schregardus (1999) an Ohio Court of Appeals supported the position that fractures in fine-grained glacial tills had to be considered when reviewing a site for the potentially contaminating land use of a solid waste landfill.

ACKNOWLEDGEMENTS. The authors specifically acknowledge the strong support for DRASTIC and the county-based Ground Water Pollution Potential mapping effort here in Ohio. Without the continued resolute efforts of the chiefs of the Division of Water at ODNR over the past two decades (Bob Goettemoeller, Jim Morris, Michele Hoffer, and Dick Bartz), it is doubtful that the dedicated mapping efforts from the staff in the Water Resources Section would have continued to the current level of completion. Thanks are also due to Mike Baker, current Chief, Division of Drinking and Ground Water, OEPA. It was Mike, spearheading the Wellhead Protection Program, now Source Water Protection Program, at OEPA who recognized the value of DRASTIC mapping for ground water protection of public water supplies. He championed the effort to find federal funding to continue the mapping effort, and it is his staff in the Source Water Protection Program section of the Division who most actively utilize Ohio's DRASTIC maps as they work to designate the Source Water Protection areas for each public water supply in Ohio.

Peter Precario, attorney at law, water law expert, and one of Earl Murphy's students at The Ohio State University, provided an additional review of the legal portions of this paper to insure the correctness of our legal footings. Tim DeWitt, former Director of the Delaware County (Ohio) Regional Planning Commission, and now Executive Director of the Bluegrass Conservancy, provided an independent practical planning review.

LITERATURE CITED

Aller L, Bennett T, Lehr J, Petty R, Hackett G. 1987. DRASTIC: a standardized system for evaluating ground water pollution using hydrogeologic settings. Washington (DC): US Environmental Protection Agency. EPA/600/2-87/035. 455 p.

Angle MP, Ziss B, Bonifas C. 2003. Ground water pollution potential products of Williams County. www.dnr.state.oh.us/water/gwppmaps/CountyPages/Williams.htm. Accessed 27 Aug 2004.

Bennett & Williams, Inc. 1990. Amanda, Marion, and Spencer Townships, Allen County, Ohio: Sole Source Aquifer Petition. Columbus, OH. 158 p.

Brockman CS, Szabo JP. 2000. Fractures and their distribution in the tills of Ohio. Ohio J Sci 100(3/4):39-55.

C/F Water et al. v. Schregardus. 1998. Ohio Environmental Review Appeals Commission.

C/F Water et al. v. Schregardus. 1999. Court of Appeals of Ohio. Tenth Appellate District, Franklin County. (Appeal upheld from 1998 WL 93972 1). Nos. 98AP-1481, 98AP-1482.

Cline v. American Aggregates Corp. 1984. Supreme Court of Ohio. 15 Ohio State 3rd 384. No. 83-1910.

Domenico PA, Schwartz FW. 1997. Physical and chemical hydrogeology. 2nd edition. New York: J Wiley. 640 p.

Frazier v. Brown. 1861. Supreme Court of Ohio. 12 Ohio State 294.

[MCD] Miami Conservancy District. 2004. Groundwater fundamentals. www.miamiconservancy.org/Great_Miami_River_Watershed/Groundwater%20Fundamentals/Groundwater_Fundamentals.htm. Accessed 27 Aug 2004.

Ng L. 1989. A DRASTIC approach to controlling groundwater pollution. Yale Law J 773. 16 p.

[OEPA] Ohio EPA. 2004. Sole source aquifers in Ohio. www.epa.state.oh.us/ddagw/pdu/swap_ssa.html. Accessed 27 Aug 2004.

Read MC. 1880. Water supply of drift-clay lands of Ohio. Ohio State Board of Agriculture 34th annual report for the year 1879. Available from: State Library of Ohio. p 491-8.

Smith C. 2004. Personal communications. Ohio EPA Div Of Drinking and Ground Water Source Water Protection Section.

Szabo JP. 2006. Textural and mineralogical characteristics of tills of northeastern and north-central Ohio. Ohio J Sci 106(2): 9-16.

[US EPA] United States Environmental Protection Agency. 2004a. Petitioners guidance sole source aquifer designation. EPA Docu-

ment 440/6-87-003. www.epa.gov/region02/water/aquifer/petition/. Last update Wednesday, 25 Jun 2003.

[US EPA] United States Environmental Protection Agency. 2004b. The Safe Drinking Water Act. www.epa.gov/safewater/sdwa/index.html. Accessed 27 Aug 2004.

[US EPA] United States Environmental Protection Agency. 2004c. Wellhead protection (WHPP) program. www.epa.gov/safewater/whpnp.html. Last update Tuesday, 26 Nov 2002. Accessed 27 Aug 2004.

[US EPA] United States Environmental Protection Agency. 2004d. Source water assessment. www.epa.gov/safewater/protect/assessment.html. Accessed 27 Aug 2004.

[US EPA] United States Environmental Protection Agency. 2004e. Dayton, OH. www.epa.gov/safewater/protect/casesty/dayton.html. Accessed 27 Aug 2004.

Village of Wilsonville v. SCA Services, Inc. 1981. Supreme Court of Illinois. 86 Ill 3rd 1, 426 N. E. 2nd 824. No. 52885.

Ward A, Trimble S. 2004. Environmental Hydrology. 2nd edition. Boca Raton (FL): Lewis Publishers. 475 p.

Weatherington-Rice J, Christy AD, editors. 2000. Fractures in Ohio's glacial tills: a special issue of The Ohio Journal of Science. Ohio J Sci 100(3/4):36-112.

Weatherington-Rice J, Christy AD, Angle MP, Aller L. 2006. DRASTIC hydrogeologic settings modified for fractured till: Part 1. Theory. Ohio J Sci 106(2):45-50.

Weatherington-Rice J, Christy AD, Forsyth JL. 2000. Ohio's fractured environment: introduction to The Ohio Journal of Science's special issue on fractures in Ohio's glacial tills. Ohio J Sci 100(3/4):36-8.